Why the MPCA proposes using EC_{10} instead of NOEC to identify a protective concentration of sulfide with dose-response data

EC_{10} The concentration that causes a 10% reduction in growth or survival.

NOEC The highest concentration tested that is not significantly different from the control. "No Observed Effect Concentration"

Wild Rice Standards Study Advisory Committee Meeting
July 14, 2015

Minnesota Pollution Control Agency

CLEAN WATER LAND & LEGACY AMENDMENT

Use of EC_{10} is consistent with the recommendations of ecotoxicology experts

For instance, the USEPA Science Advisory Board stated*:

"…When appropriate data are available, ECx values (i.e., the concentration causing an effect in x percent of the test organisms) should be used rather than NOECs/LOECs (i.e., no observed effects concentrations/lowest observed effects concentrations). The ECx value reflects the information in the entire concentration-response curve and confidence intervals can be calculated as part of the curve fitting process. In contrast, the use of NOECs or LOECs by hypothesis tests are dependent upon the test concentrations that are used, the variability of the experimental technique, and the power of the statistical test."

"Curve fitting, which uses more of the information contained in a data set and enables derivation of confidence intervals in the estimation of the ECx, is the preferred method for representing dose (concentration)-response information. The selection of a specific ECx value for derivation of an aquatic life criterion depends upon the level of protection or effect that decision makers are willing to accept or detect in the field. However, an EC_{20} has been used for most species and an EC_{10} has been used for threatened and endangered species."

*From: SAB Advisory on Aquatic Life Water Quality Criteria for Contaminants of Emerging Concern. December 18, 2008
http://nepis.epa.gov/EPA/html/DLwait.htm?url=/Exe/ZyPDF.cgi/P1002U38.PDF?Dockey=P1002U38.PDF

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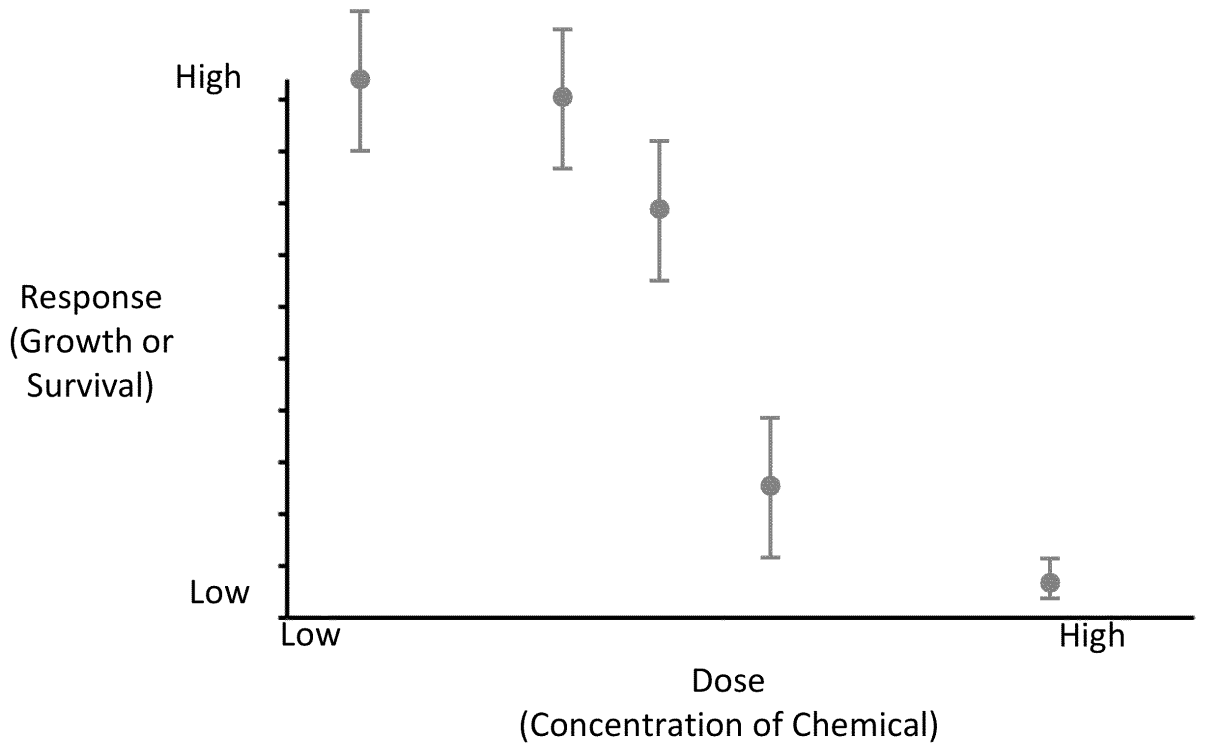
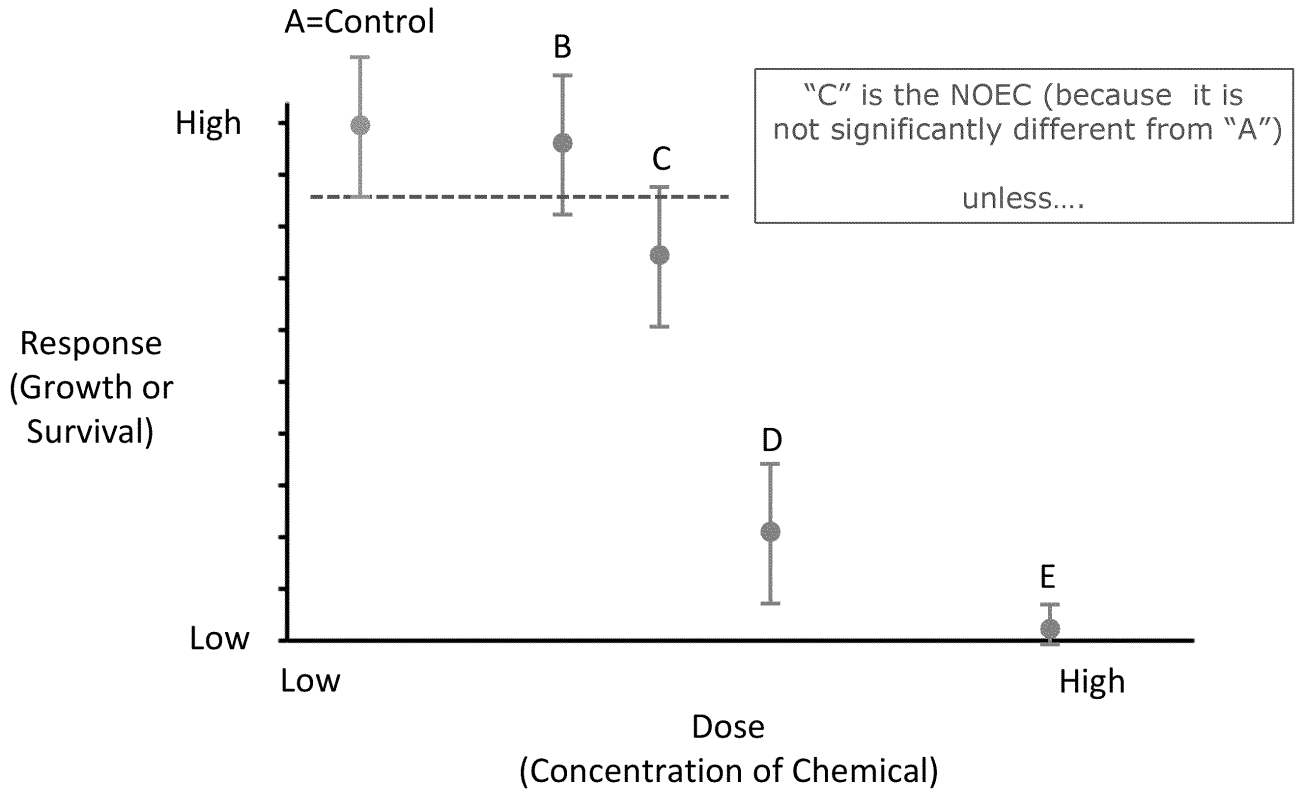
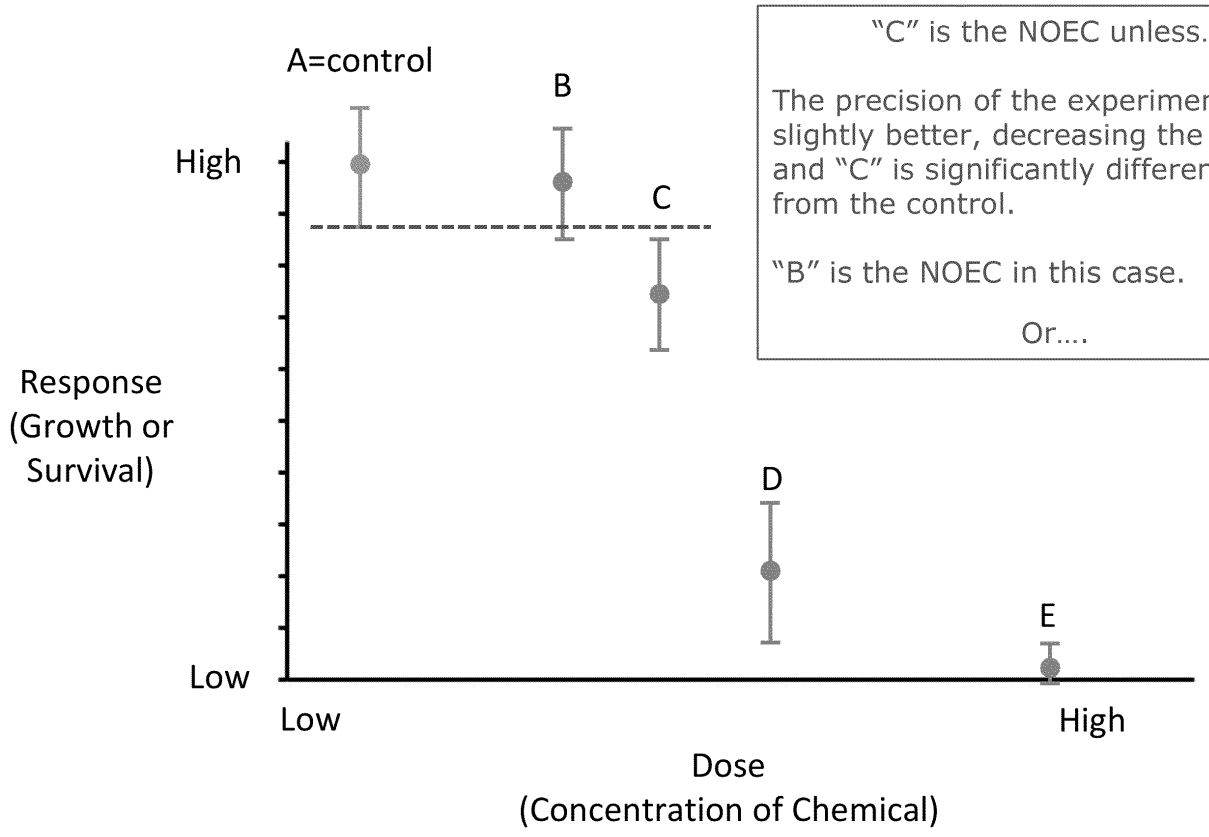
Illustrative experimental response data at 5 concentrations, showing mean ± 95% Confidence Interval (95% CI)



NOEC is the highest concentration tested that is not significantly different from the control (the 95% CI bars overlap)



But the particular value of the NOEC is dependent on happenstance and the precision (size of 95% CI) of the data



"C" is the NOEC unless….

The precision of the experiment was slightly better, decreasing the 95% CI, and "C" is significantly different from the control.

"B" is the NOEC in this case.

Or….

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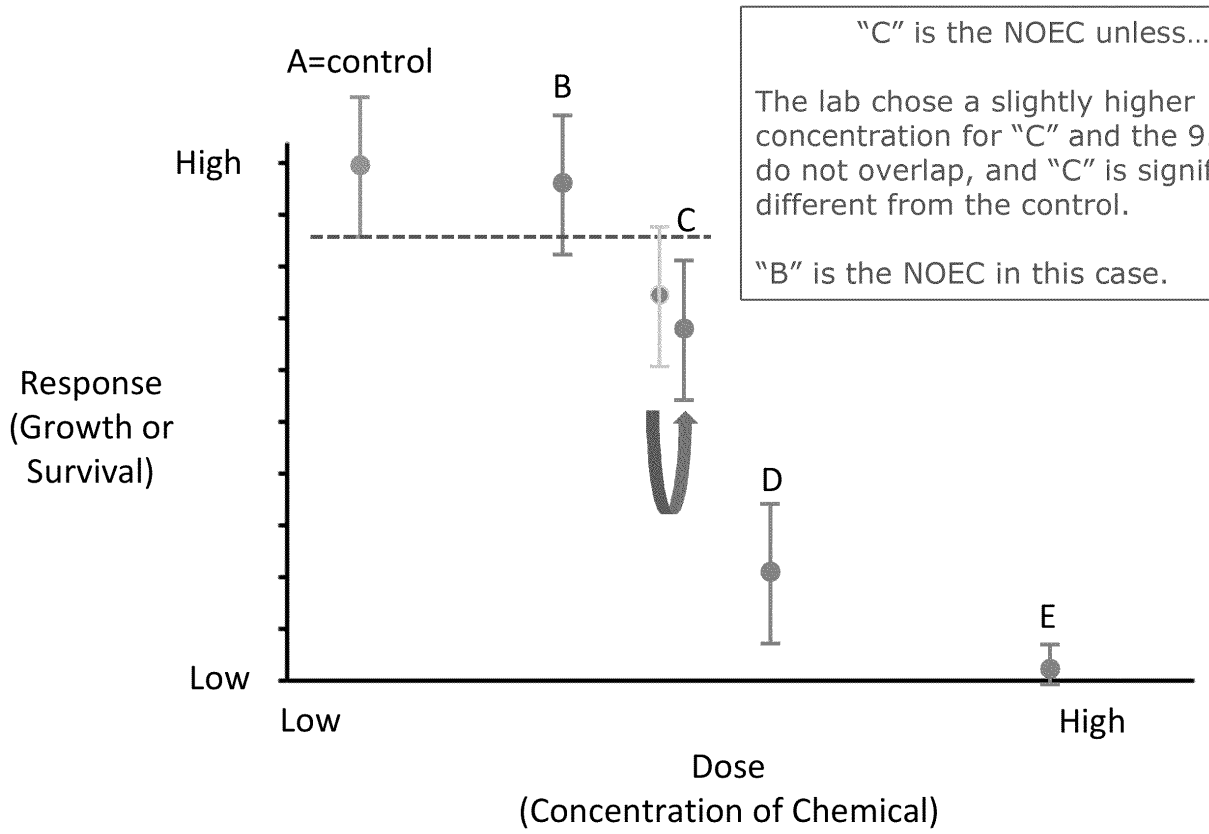
Slight differences in the concentration of treatments can change which treatment is identified as the NOEC

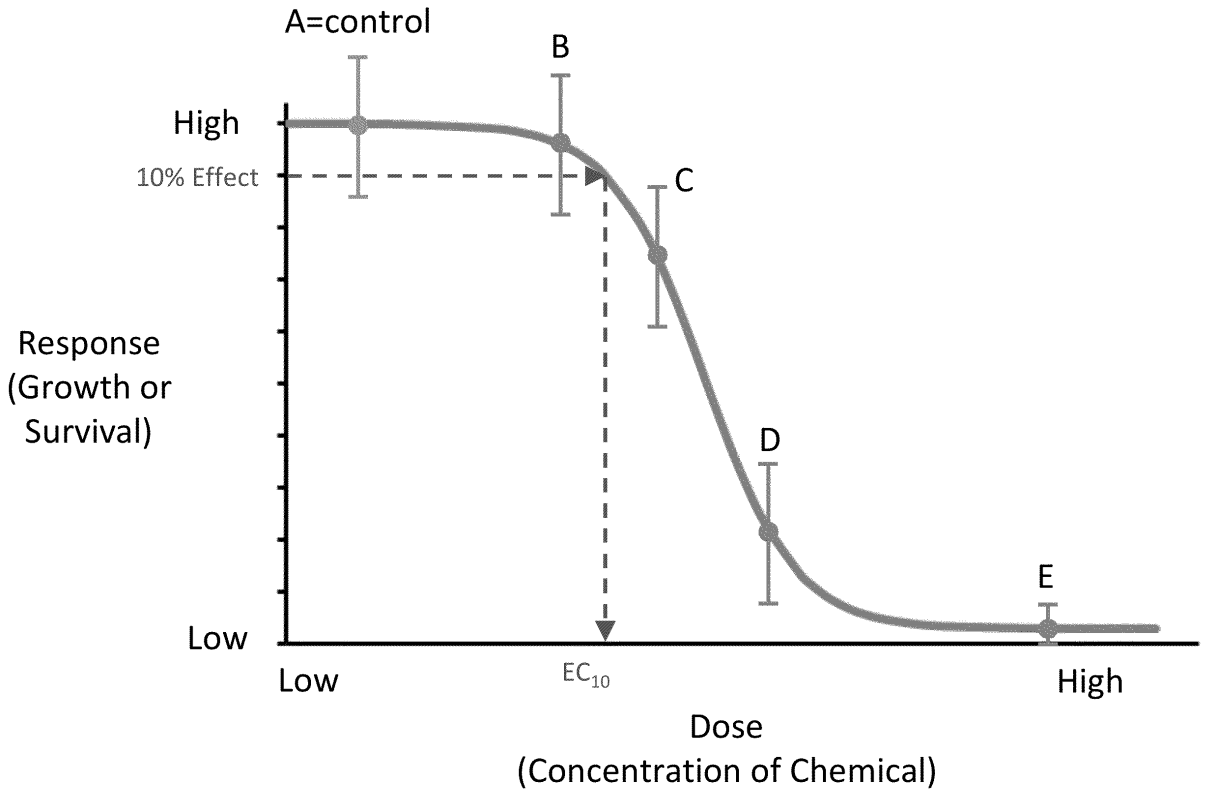


"C" is the NOEC unless….

The lab chose a slightly higher concentration for "C" and the 95% CI do not overlap, and "C" is significantly different from the control.

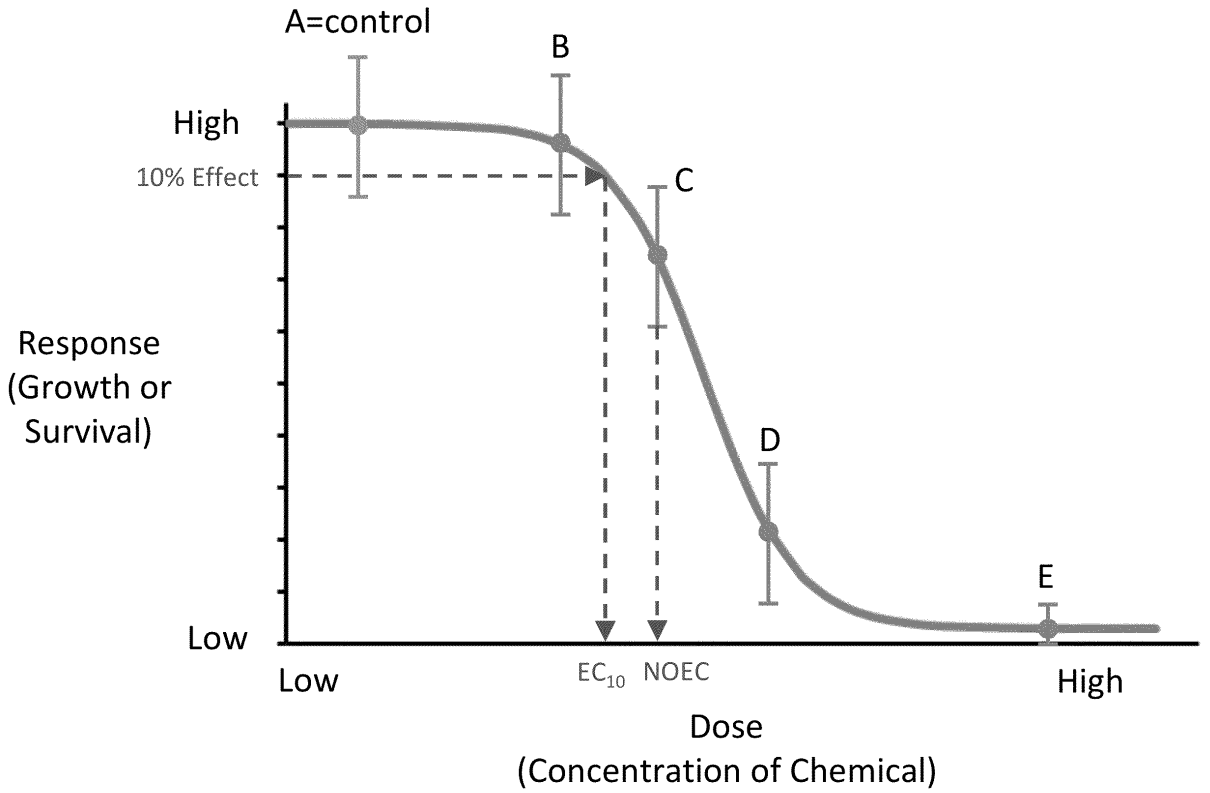
"B" is the NOEC in this case.

Instead of identifying a NOEC by statistical comparison of the doses that the lab happened to choose, ecotoxicologists recommend fitting a curve to the data and calculating "Effect Concentrations." EC_{10} is shown below.

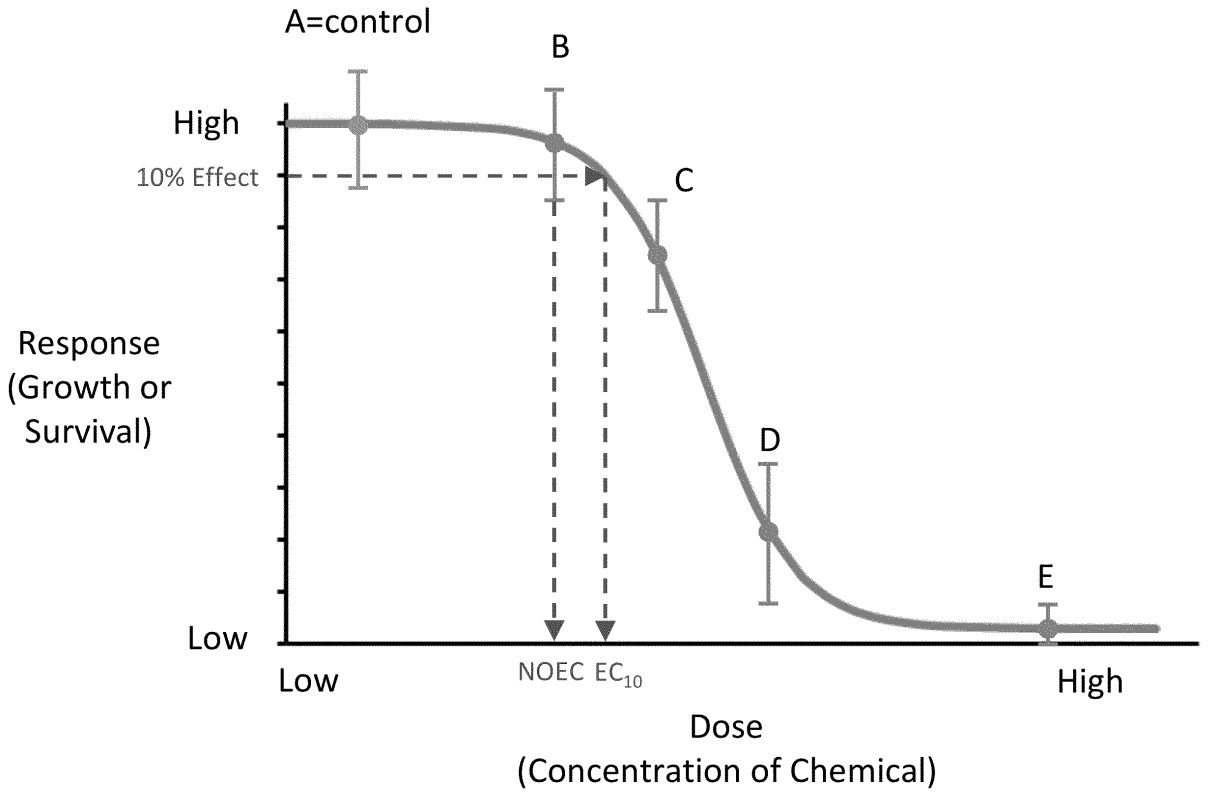


NOEC will be either <EC_{10} or >EC_{10} depending on:
(1) response precision and (2) choice of test concentrations

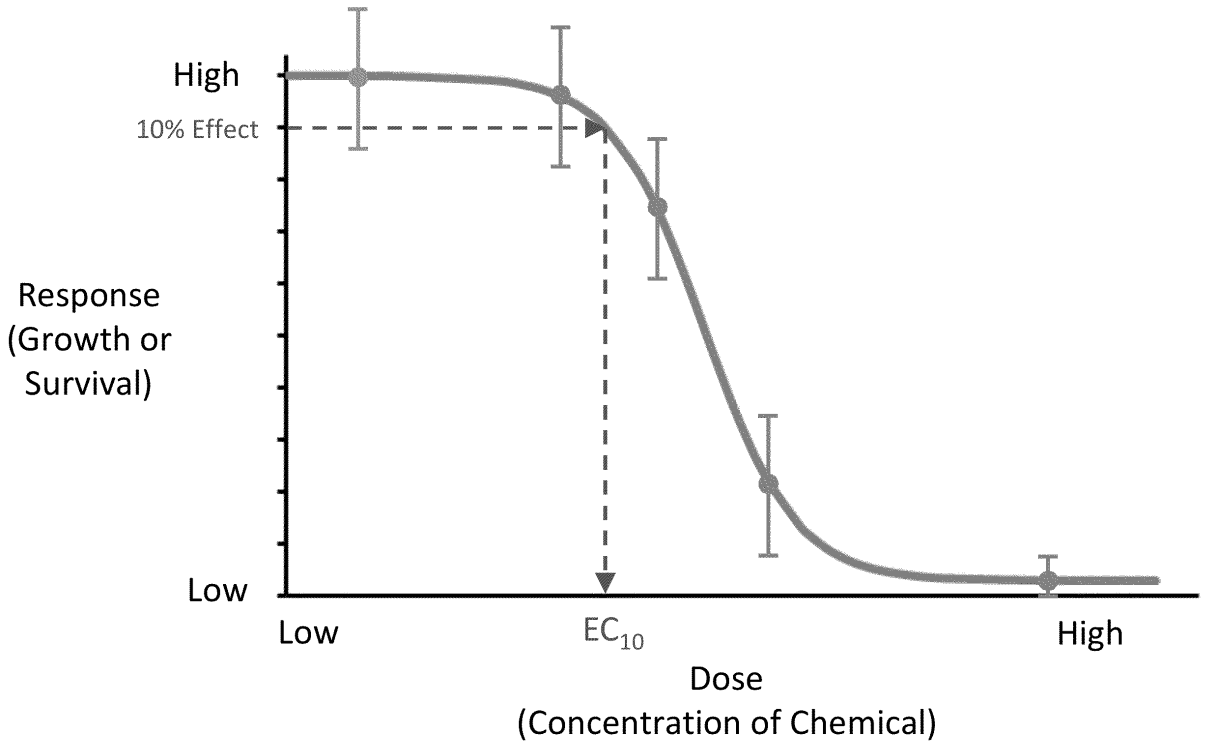
Here NOEC is >EC_{10} because the vertical confidence intervals are relatively large, and C is not significantly different from the control.



Here NOEC is <EC_{10} because the vertical confidence intervals are slightly smaller, and C is now significantly different from the control.
But, the EC_{10} value is much less sensitive, and is therefore more defensible.



Curve-fitting and calculation of EC_{10} is the preferred method of determining a protective concentration; EC_{10} is not strongly affected by dose choice or test precision



MPCA's use of EC_{10} is consistent with the recommendations of ecotoxicology experts

For instance, in a 2014 peer review* conducted for the USEPA, the panel stated:

"NOECs and LOECs are not preferred endpoints; ECx values are preferred endpoints. Consideration should have been provided to calculating ECx values where possible from the studies cited and to preferentially using 10 or 20% effect endpoints (e.g., EC_{10}, EC_{20}). NOECs and LOECs are not technically defensible as they do not reflect the concentration-response that forms the basis for toxicology, and they are set based on concentrations tested with associated high variability. There have been many publications and presentations on this topic. The following three publications and references contained therein summarize the problems with NOECs and LOECs:

1. Warne MS, Van Dam R. 2008. NOEC and LOEC data should no longer be generated or used. *Australas J Ecotox* 14:1–5.
2. Landis WG, Chapman PM. 2011. Well past time to stop using NOEL/LOELs. *Integr Environ Assess Manage* 7(4): vi-viii.
3. Jaeger T. 2012. Bad habits die hard: The NOEC's persistence reflects poorly on ecotoxicology. *Environ Toxicol Chem* 31: 228–229."

*From: 1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-γ-2-benzopyra (HHCB) Draft Risk Assessment. Draft Comments of Seven-Member Peer Review Panel. January 27, 2014
http://www.epa.gov/oppt/existingchemicals/pubs/HHCB_Consolidated_Peer_Review_Comments_January-27_2014.pdf

Warne and van Dam (2008)

"The term NOEC is misleading. It would be entirely appropriate for lay people, stakeholders and regulators who do not have extensive ecotoxicology knowledge, to assume that a NOEC is in fact a concentration that causes no toxic effect. However, we know this is not necessarily the case. By definition the NOEC is the highest concentration used in a toxicity test that does not cause a toxic effect that is significantly (usually set at $p \leq 0.05$) different to the control. This is not, by any means, the same as causing no effect. The magnitude of the biological effect that NOECs typically cause is 10 to 30% (USEPA 1991; Hoekstra and Van Ewijk 1993a; Moore and Caux 1997)…."

Warne and van Dam (2008) NOEC and LOEC data should no longer be generated or used. Australas J Ecotox 14:1-5.

Summary: MPCA's proposed use of EC_{10}

- Expert ecotoxicologists, the USEPA, and the Science Advisory Board (SAB) for the USEPA all recommend: Rather than using NOEC, fit a curve and calculate EC values.
- SAB: EC_{20} has been used for most species and EC_{10} has been used for threatened and endangered species.
- In the interest of protecting wild rice, MPCA proposes to use EC_{10} for porewater sulfide.